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In re Application of Alan M. Schilowitz et al	) Before the Board of Patent Appeals and Interferences) Examiner: Walter D. Griffin
U. S. Serial No. 09/978,510	) Confirmation Number: 4852
Filed: October 16, 2001	) Group Art Unit: 1764
METHOD FOR REDUCING EMISSIONS FROM HIGH PRESSURE COMMON RAIL FUEL INJECTION DIESEL ENGINES	) Family Number: P2000J095 US2

Commissioner for Patents
Mail Stop Appeal Brief - Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

APPEAL TO THE BOARD OF PATENT APPEALS AND INTERFERENCES PURSUANT TO 37 C.F.R. § 1.192

Applicants hereby appeal from the final rejection of all the claims in this case by the Examiner.

(1) Real Party in Interest

The real party in interest in this case is Applicants' assignee, ExxonMobil Research and Engineering Company.

CERTIFICATION OF FACSIMILE TRANSMISSION

[X] The undersigned hereby certifies that this correspondence will be facsimile transmitted to the Commissioner for Patents facsimile number 1-703-872-9306 on the date shown below.

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Name of person signing certification	Signature	Date

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(2) <u>Related Appeals and Interferences</u>

There are no other appeals or interferences pending in this or any related applications which will directly affect or be directly affected by or have a bearing on the Board's decision in this pending appeal.

(3) <u>Status of Claims</u>

Claims 1, 3, 7, 9, 11 and 12 are pending in the case and stand rejected by the Examiner under 35 USC § 103(a).

(4) <u>Status of Amendments</u>

Appellants submitted an Amendment after Final Rejection on April 28, 2004 and received an Advisory Action mailed May 11, 2004 indicating the Amendment was entered and considered but was not deemed to place the application in condition for allowance. No other papers have been submitted since receipt of the Advisory Action.

(5) <u>Summary of Invention</u>

The present invention is directed to the discovery that a high pressure common rail fuel injected diesel engine can be run at a reduced emissions output level using a low density diesel fuel without the same level of power loss as is experienced by ordinary diesel engines run on low density fuels (page 2, paragraph [0005], lines 12-21; page 3, paragraph [0007], lines 6-13; page 5, paragraph [0014], lines 20-24; page 6, paragraph [0017], lines 14-17).

The fuel employed is characterized as one having a density of about 0.825 g/cc or less (page 2, paragraph [0005], line 16), a viscosity of about 2.6 cSt or less at 40°C (page 2, paragraph [0005], line 18), and a sulfur content of about 0.05 wt% or less (page 2, paragraph [0006], line 23).

Issues

Whether the Examiner properly rejected claims 1, 3, 7, 9, 11 and 12 under 35 USC § 103(a) based on Barry et al, USP 5,976,201.

Grouping of the Claims

Appellants elect to have the claims treated as a single group.

Argument

It is maintained that the Examiner's rejection of claims 1, 3, 7, 9, 11 and 12 under 35 USC § 103(a) based on Barry et al, USP 5,976,201 is not correct.

The present invention is directed to the discovery that high pressure common rail fuel injected diesel engines can be run at a reduced emission output level using lower density fuels with a smaller loss in power than one would usually expect from the use of such lower density fuels in diesel engines based on the teachings in the literature. Such avoidance of significant power loss is achieved using the lower density fuel at the same fuel flow rate in the engine as is used for the more usual higher density fuels.

The Examiner rejects the claims as obvious over Barry et al.

The Examiner argues that the Barry reference discloses a diesel fuel having a specific gravity typically in the range of 0.82 to 0.83 g/cc, a viscosity typically in the range of from 1.7 to 1.9 cSt at 40°C and a sulfur content of no greater than 0.1 wt%, with a specific example of a fuel with a sulfur content of 0.01 wt%.

The Examiner acknowledges that the reference does not disclose the use of the fuel in a high pressure common rail fuel injection system compression ignition engine.

Despite the acknowledged deficiency, the Examiner argues that it would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the teachings of the Barry reference by utilizing the fuel of Barry in a common rail fuel system compression ignition engine because one would utilize a known diesel fuel in any diesel engine regardless of the specific use and expect the engine to work effectively.

The Examiner rejects Appellants arguments that the use of a lower density fuel in high-pressure common rail fuel injection diesel engine unexpectedly does not result in power loss. The Examiner argues that the literature regarding such engines disclose that such engines result in higher fuel efficiency, better engine performance and better vehicle response and acceleration as compared to conventional diesel engines. The Examiner concludes that the power loss amounts referred to by Applicants are not unexpected in view of the inherent advantages of high pressure common rail fuel injected diesel engines.

Appellants traverse this rejection.

The present invention is directed to the reduction of emissions from high pressure common rail fuel injection system diesel engines by use of low density diesel fuel of lower viscosity, the reduction in emission being achieved without significant power loss.

It is generally recognized in this art that different applications often require different grade fuels having specific performance specifications. For example, Barry states that "[a] number of performance specifications have been established for diesel fuels of different grades depending upon service application". Barry, column 1, lines 15-17. Barry disclosed and claims a fuel diesel composition that exhibits low emissions and some other properties, which is <u>suitable for use in underground diesel-engine</u>

mining equipment. Barry does not suggest the use of such low emissions diesel fuel in common rail fuel system compression ignition engines. Underground diesel-engined mining equipment typically utilize conventional diesel engines while the present invention relates to high pressure common rail fuel injection system compression ignition engines.

That low density fuels are environmentally preferred from an emissions stand point is already taught in the literature and is acknowledged in the present specification.

What is surprising is that such lower density diesel fuel can be used in high pressure common rail fuel injected diesel engines with a smaller loss in power than one has come to expect in regard to the use of such fuels in other types of diesel engines based on the teachings of the literature. See: Automotive Fuels Handbook, published by the Society of Automotive Engineers, Inc., 1990 by Owen and Coley, pages 340-344(copy previously provided).

That article shows that fuel density is an important fuel characteristic with respect to fuel injection equipped diesel engines, that power goes down as fuel density decreases. The article suggests that a way to compensate for this power loss is to adjust the injection pump delivery for equal power to eliminate the density effect.

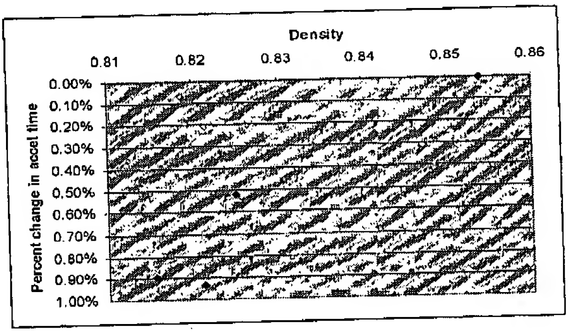
In other diesel engines, fueled by systems other than the high pressure common rails, fuel injected engines demonstrated in the present application, low density diesel fuels reduce emission but at reduced power. As is shown in the SAE reference, reduction in fuel density is associated with engine power loss.

As is shown in the present application, even the high pressure common rail fuel injected diesel engine exhibited a slight loss in engine power when run on diesel fuel of lower density.

To determine, however, if the slight differences in acceleration shown by the data in the present application is expected or unexpected, the data is analyzed below.

Fuel	Density (g/c)	Accel. Time (sec.)	Density % Difference From Base Fuel	Accel. Time % Difference From Base Fuel
UK LS ADO (base)	0.8539	26.61	0.00	0.00
Swiss LS ADO	0.8251	26.75	-3.49	0.52
R-Improved ADO	0.8212	26.86	-3.98	0.93
Swedish Class 1 ADO	0.815	26.85	-4.71	0.89

A plot of density vs. percent change in power loss is presented in the Figure below:



A linear fit of the plot gives a slope of 0.24% power loss percent for every 0.01 g/cc change in density. Expressed differently, a change of 0.04 gm/cc results in approximately a 1% power loss.

Attention is now directed to the information presented in Figure 1 of the SAE reference. That Figure was reproduced from a paper by P. Heinze which was published in 1986: Institute of Mechanical Engineers International Conference on Petroleum

Based Fuels and Automotive Applications, Paper No. C306/86 (copy previously provided).

In Figure 1 of that article discrete data points are presented only for Engine D. There are no data points presented for any of the other engines. All that is presented for the other engines are estimated straight line regressions.

Aside from Engine A, all the other engines showed a larger response (greater power loss) to density reduction than the high pressure common rail fuel injection system diesel engine exemplified in the present invention.

Engine D in Figure 1 shows the largest power loss as density decreases. In Section 3.1 of the paper "Engine Performance and Emissions with Future Type Diesel Fuels" P. Heinze (C306/86) at page 89, it is reported that Engine D exhibited a 1.6% power increase per 0.01 g/ml density increase. Expressed differently this is a 1.6% power loss per 0.01 g/ml (0.01 g/cc) density decrease.

Engine G in Figure 1 has the smallest density effect (aside from Engine A to be addressed below). For Engine G the power loss/density slope can be estimated from the Figure 1 at delta y = 2.5% / delta x = [0.875 - 0.835] = 0.04. This works out to approximately 0.63% power loss for a density reduction of 0.01 gm/cc. This is more than two and a half times greater than the 0.24% power loss for a density reduction of 0.01 gm/cc shown in the present invention for the high pressure common rail fuel injected diesel engine.

Engine A has the smallest density effect. For Engine A the power loss is reported in Section 3.1 of C306/86 at page 89 as being 0.4% per 0.01 g/ml density decrease which, it must be noted, is still greater than the 0.24% power loss per 0.01 g/ml density decrease exhibited by the high pressure common rail fuel injected engine as discovered and reported in the present invention and application. While on its face

this would appear to indicate that in Engine A the lower density fuel effect is trending in the same or similar direction as the discovery that forms the bases of the present invention, this interpretation would not be complete.

Of the nine (9) engines evaluated on fuels of different densities and reported in Figure 1 of the SAE paper and in C306/86, eight (8) engines showed significant, substantial power losses as the fuel density decreased, the power loss ranging from somewhere about 0.63% power loss per 0.01 g/cc density reduction to 1.6% power loss per 0.01 g/cc density reduction, these power losses being from more than 2.5 to more than 6 times the power loss per 0.01 g/cc density reduction of the present invention with common rail fueled diesel engines.

One of ordinary skill in the art, with this type of information before him would have no basis upon which to base an expectation or to predict that in high pressure common rail fueled injected diesel engines, a percent power loss of only 0.24% per 0.01 g/cc density reduction would be obtained while still achieving reduced emissions. On the contrary, one would not know nor could it even be guessed what the percent power loss per 0.01 g/cc density reduction would be for the engine. Therefore, while it might be obvious to try fuels of different lower density in any diesel engine to achieve an expected reduction in emissions, one would expect a power loss to be sustained, with no real expectation that it would not be somewhere between about 0.63% to 1.6% power loss per 0.01 g/cc density reduction, the type of data reported for eight (8) of the nine (9) engines tested. Indeed, even considering all nine (9) fuels, the power loss ranged from 0.4% to 1.6% power loss per 0.01 g/cc density reduction which is even at the low end about double the 0.24% power loss per 0.01 g/cc density reduction observed in the present invention. Because all engine types are different it was not possible to predict based on any of the showing of the references that the power loss in high pressure common rail fuel injected diesel engines would be only about 0.24% per 0.01 g/cc density reduction in the diesel fuel used to power the engine and that low

density fuel would or could achieve both emissions reduction and minimal power loss in such engines.

Engine A does not demonstrate the present invention: it does not demonstrate the same reduction in emissions with a minimal percent power loss.

Reference is made to Figure 6 in the 1986 paper C306/86. Figure 6 reports the level of emissions for six (6) engines including Engine A. In the 1986 paper, the density range for emission testing is 0.874 to 0.837 g/cc. Figure 6 shows the general emissions trend for Engines A, B, E, F, G and H.

In the present invention, over a density range of 0.8539 to 0.8155 g/cc (delta of 0.0384 g/cc), HC goes down significantly, CO goes down significantly, and NO_x remains relatively unchanged while percent power loss, as previously demonstrated, goes down relatively insignificantly (0.24% power loss per 0.01 g/cc density reduction).

Engine A showed a relatively smaller CO emissions reduction benefit from the use of low density fuel. Engine A is a direct injection engine and emissions data are shown in Figure 6. The data for CO are most telling. Over the range of densities tested in the present invention (0.8539 → 0.8155 g/cc for a density delta of 0.0384 g/cc) a CO reduction of at least 63% was achieved (CO went from 0.77 down to about 0.28). The emissions testing results presented in the present invention were generated using the regulated emissions test cycle. Engine A shows a CO reduction of about 25% over a density range of between about 0.860 to 0.837 g/cc for a delta of 0.023 g/cc. While it is to be noted that in Figure 6 the x axis is cetane, reference to Table 1 of Paper No. C306/86 reveals that the fuel with the cetane of 53 had a density of 0.837 g/cc while the fuel with a cetane of about 46 had a density of 0.860. Extrapolating to a cetane of about 41 (density of about 0.874 g/cc) one would expect engine A to exhibit a change in CO of from about 7.3 down to about 4.5 for an about 38% reduction in CO over a

density change of about 0.038 g/cc, the same density change as exemplified in the present application. Based on the results presented in the Paper No. C 306/86 it is maintained that there is no way to derive from these results that one could or would expect large emission reduction benefits (greater than about 60% CO reduction over a Δ density of about 0.038 g/cc) AND low power loss in high pressure common rail fuel injected vehicles (0.24%/0.01 g/cc density reduction, versus the best data in C306/86 of about 0.4%/0.01 g/cc density reduction), as demonstrated in the present invention.

Thus, Engine A does not achieve the same reduction in emissions at minimum % power loss as is demonstrated in the present invention. Engine A achieves (based on extrapolation) about a 38% reduction in CO, whereas in the present invention a CO reduction of greater than about 60% is achieved over the same change in density (about 0.038 g/cc) and at a low loss of power.

Consequently, with the present art before him one skilled in the art would not know what to expect when using a diesel fuel of reduced density <u>in a high pressure common rail fuel injected diesel engine</u>. It is not at all apparent that in a high pressure common rail fuel injection system diesel engine a diesel fuel of reduced density will reduce CO and HC emission while holding NOx at least constant and at a percent power loss of only about 0.24% per 0.01 g/cc density reduction as demonstrated in the present case as compared against the results from C306/86 for which 8 of 9 engines showed percent power loss ranging from about 0.63 to 1.6% per 0.01 g/cc density reduction while for Engine A a percent power loss of about 0.40% per 0.01 g/cc density reduction is accompanied by a reduction in CO of only about 38% versus the present invention wherein a percent power loss of about .24%/0.01 g/cc density reduction is accompanied by about a 63% reduction in CO exemplified in the present invention for common rail fueled diesel engines.

Thus, while Barry et al discloses a lower density diesel fuel, and while high pressure common rail fuel injected diesel engines are described in the current literature (2000-2004) and such engines are indeed described as giving drivers the benefits of lower fuel consumption, better engine performance, less noise, higher power and better vehicle response and acceleration, there is no possible way to know, expect or predict just how such high pressure common rail fuel injection diesel engines will respond to or perform on low density diesel fuels.

Such statements regarding the high pressure common rail fuel injected diesel engine's superiority regarding power, vehicle response and acceleration are all in comparison to and with respect to the conventional diesels and make no allegations regarding engine performance as a function of fuel type.

To "expect the engine to work effectively" is a statement of the basis of the "obvious to try" standard which is not a ground for rejecting a claim. To expect the engine to work effectively does not necessarily mean that the engine will not experience a power loss (evidenced by a reduction in acceleration) commensurate with and in line with and the same degree as the power losses which are commonly experienced with conventional diesel engines when one switches from a high density to a low density fuel. To work effectively is what is minimally expected, that the engine will run, will not stall, and will not excessively pollute. It could even be argued that it is obvious to try using vegetable oil or jet fuel or just about any heavier hydrocarbon fuel in a diesel engine and expect the engine to work. Just <u>how</u> effective that working would be and how the engine performance would be effected by such fuel is not known or obvious. The result is not obvious!

Based upon the prior art the best that could be expected in terms of "working effectively" would be that the new engine, despite being more powerful, lower polluting and having higher absolute power, vehicle response and acceleration, <u>would still exhibit</u>

the tendency common to the other diesel engines of significant power loss upon switching from high density to a lower density diesel fuel and to the same degree.

While it may be obvious to try using just about any "diesel" fuel in any "diesel engine" it is not obvious just how diesel engines of different types will respond to diesel fuels of different types. The result obtained in the present invention, the reduction in polluting emissions at a minimal loss in power when the high pressure common rail fuel injected diesel engine is run on lower density fuel is an unexpected result, it could not be predicted based on the information available in the literature.

To repeat, that it may have been obvious to try using the lower density fuel in such a high pressure common rail fuel injected diesel engine is not the proper basis for a rejection.

Common, ordinary diesels loss power when switched from high density fuel to low density fuel. Nothing in the literature, including the teaching that high pressure common rail fuel diesel engine are of higher power, better acceleration and have better vehicle response than common ordinary diesel would lead one necessarily to expect that were as the ordinary diesel loses significant power when switched from high density to low density fuel, the high pressure common rail diesel engine will be found not to experience or evidence the same degree of power loss. The discovery that high pressure common rail diesel engines do not suffer the same degree of power loss as experienced by ordinary diesel engines upon switching from high density to low density fuel and that emission are kept low is the unexpected result and the essence of the presently claimed invention. This is not taught, suggested or implied in the art.

Relief Sought

It is requested that the Board reconsider the case in light of the above argument and remarks that it reverse the Examiner, withdraw the rejection, allow the claims and direct that the case be passed to issue in due course.

Respectfully submitted,

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[X] Pursuant to 37 CFR 1.34(a)

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APPENDIX

Claim 1. A method for reducing emissions of common rail fuel system compression ignition engine without substantial reduction in acceleration, the method comprising running said engine on a fuel comprising a diesel fuel characterized by having a density of about 0.825 g/cc or less, a viscosity of about 2.6 cSt or less at 40°C, and a sulfur content of about 0.05 wt% or less.

Claim 2. (Cancelled)

Claim 3. The method of claim 1 wherein said density is about 0.820 g/cc or less.

Claims 4, 5, 6. (Cancelled)

Claim 7. The method of claim 1 wherein said viscosity is about 2.1 cSt or less at 40°C.

Claim 8. (Cancelled)

Claim 9. The method of claim 3 wherein said viscosity is about 2.1 cSt or less at 40°C.

Claim 10. (Cancelled)

Claim 11. The method of claim 1, 3, 7 or 9 wherein said sulfur content is about 0.04 wt% or less.

Claim 12. The method of claim 11 wherein said sulfur content is about 0.03 wt% or less.